

AMENDMENTS TO THE SPECIFICATION

Please amend the Specification as follows. Insertions are shown underlined while deletions are ~~struck-through~~.

The paragraph beginning at page 1, line 5:

This invention relates to an electrochemical cell used in a storage device such as a secondary battery and an electric double-layer capacitor, and relates to an electrode suitable for the cell.

The paragraph beginning at page 1, line 9:

~~There have been suggested and practically used~~ Storage devices such as secondary batteries and capacitors, in which a proton-conducting polymer is used as an electrode active material, have been suggested and practically used. FIG. 1 is a cross-sectional view illustrating a conventional electrochemical cell.

The paragraph beginning at page 1, line 14:

As shown in FIG. 1, a conventional electrochemical cell has a structure where a cathode 3 containing, e. g., a proton-conducting polymer as an electrode active material is formed on a cathodic current collector 1 while an anode 4 is formed on an anodic current collector 2, and these electrodes are combined via a separator 5 ~~and~~ where only protons act as a charge carrier. Also, the cell is filled with an aqueous or non-aqueous solution containing a proton-donating electrolyte as an electrolytic solution, and is sealed by a gasket 6.

The paragraph beginning at page 1, line 23:

The cathode 3 and the anode 4 are formed using electrode materials including an electrode active material comprising a powdery doped or undoped proton-conducting polymer as a main component, a conductive auxiliary and a binder. These electrodes can be formed by (1) a method comprising the steps of placing the electrode materials in a mold with a predetermined size and molding it by a hot press to form an electrode, or (2) a method comprising the steps of coating the a slurry of the electrode materials on a current collector surface by screen-printing and drying the

Appl. No. : 10/827,074
Filed : April 19, 2004

resulting film to form an electrode. Then, ~~a~~the cathode and ~~an~~the anode thus formed are mutually faced via a separator to give an electrochemical cell.

The paragraph beginning at page 2, line 10:

Examples of a proton-conducting compound used as an electrode active material include π -conjugated polymers such as polyaniline, polythiophene, polypyrrole, polyacetylene, poly-p-phenylene, polyphenylene-vinylene, polyperinaphthalene, polyfuran, polyflurane, polythienylene, polypyridinediyl, polyisothianaphthene, polyquinoxaline, polypyridine, polypyrimidine, polyindole, polyaminoanthraquinone, polyimidazole and their derivatives; indole π -conjugated compounds such as an indole trimer compound; quinones such as benzoquinone, naphthoquinone and anthraquinone; quinone polymers such as polyanthraquinone, polynaphthoquinone and polybenzoquinone where a quinone oxygen can be converted into a hydroxyl group by conjugation); and proton-conducting polymer prepared by copolymerizing two or more of the monomers giving the above polymers. These compounds may be doped to form a redox pair for exhibiting conductivity. These compounds are appropriately selected as a cathode active material and an anode active materials, taking a redox potential difference into account.

The paragraph beginning at page 3, line 4:

Known electrolytic solutions include an aqueous electrolytic solution consisting of an aqueous acid solution and a non-aqueous electrolytic solution comprising an electrolyte in an organic solvent. In an electrode comprising a proton-conducting compound, ~~the former~~above aqueous electrolytic solution is frequently used because it can give a high-capacity electrochemical cell. The acid used may be an organic or inorganic acid; for example, inorganic acids such as sulfuric acid, nitric acid, hydrochloric acid, phosphoric acid, tetrafluoroboric acid, hexafluorophosphoric acid and hexafluorosilicic acid and organic acids such as saturated monocarboxylic acids, aliphatic carboxylic acids, oxycarboxylic acids, p-toluenesulfonic acid, polyvinylsulfonic acid and lauric acid.

The paragraph beginning at page 3, line 18:

Appl. No. : 10/827,074
Filed : April 19, 2004

When using an indole trimer compound as an electrode active material in an electrochemical cell having such a structure, energy is stored by an electrochemical redox reaction illustrated by reaction equation (1) of the electrode active material with ions in the electrolytic solution. In the equation, the first step reaction is a doping reaction wherein X^- represents a dopant ion such as sulfonate and halide ions, which can dope a proton-conducting compound to endow the compound with electrochemical activity. The second step reaction is an electrochemical reaction (electrode reaction) involving bonding and elimination of protons in the doped compound.

The paragraph beginning at page 5, line 16:

In this test ~~was used~~ was a working electrode prepared by film coating by applying a slurry mixture of the electrode active material and an anion-exchange resin fiber to a conductive substrate. A counter electrode and a reference electrodes were Pt and Ag/AgCl electrodes, respectively. In this test, constant-current charge/discharge and ~~a~~-constant-current/voltage charge/discharge (constant-voltage time: 12 hours) were conducted, respectively. A test temperature was 25°C.

The paragraph beginning at page 5, line 25:

FIG. 2 is a graph showing the results of the current-constant test (cycle test) and the current/voltage-constant test (constant-voltage retention test). The graph was a plot in which an abscissa and an ordinate are ~~a~~-total time of the test and ~~a~~-remaining capacity, respectively. The results show that repetition of charge and discharge ~~is more significantly to deteriorations in~~ cycle-life properties than does ~~a~~-voltage-constant time. That is, it can be concluded that the more the interaction between the electrode active material and ions ~~is~~, the more the significant deterioration in cycle-life properties ~~is becomes~~.

The paragraph beginning at page 7, line 12:

5-Cyanoindole trimer as a cathode active material, vapor grown carbon fiber (VGCF) as a conduction auxiliary and a polyvinylidene fluoride with an average molecular weight of 1,100 as a binder were weighed at a weight ratio of 69/23/8 in this order, and mixed by stirring using a

Appl. No. : 10/827,074
Filed : April 19, 2004

blender. Ten milligrams of the resulting mixed powder was were weighed and stirred in 1 mL of DMF at room temperature for 5 min to provide a homogeneously dispersed slurry. It was deposited on a conductive rubber current collector by screen printing and then dried to give a cathode. Separately, polyphenylquinoxaline as an anode active material and Ketjen Black (EC-600JD) as a conduction auxiliary were weighed at a weight ratio of 75/25 in this order, and mixed by stirring using a blender. Then, using the mixture and m-cresol as a solvent, an anode was prepared as described for the cathode. A 20 % aqueous solution of sulfuric acid was used as an electrolyte and a polyolefin porous membrane with a thickness of 20 μm was used as a separator. The surfaces having the cathode and the anode were combined via the separator such that they faced to each other. The assembly was impregnated with an electrolytic solution and sealed using a gasket to provide a unit cell.

The paragraph beginning at page 8, line 19:

An electrochemical cell prepared by stacking and combining in series a plurality of unit cells exhibiting variable voltage profile during charge/discharge, e. g., an electrochemical cell stack with a rated voltage of 6 V prepared by combining five unit cells with a rated voltage of 1.2 V, has the following problem. Each of the unit cells constituting the electrochemical cell stack exhibits a different voltage profile. Thus, some unit cells exhibit a voltage higher than the rated voltage 1.2 V while some unit cells exhibit a voltage lower than 1.2 V. An overvoltage is, therefore, a voltage applied to the unit cells, ~~which is with a voltage~~ higher than the rated voltage. It may accelerate deterioration in an electrolytic solution and electrode active materials to increase an internal resistance in the unit cell. Consequently, a voltage assigned to the unit cell may become higher than that assigned to another unit cell, leading to deterioration in battery properties. Finally, as repeating the charge/discharged cycle, voltage profile difference between the unit cells may become more significant, resulting in a considerably reduced cycle life.

The paragraph beginning at page 15, line 18:

Furthermore, the anion exchange resin contained in the electrode inhibits an anion doping/undoping reaction to the electrode active material to minimize voltage profile variation

Appl. No. : 10/827,074
Filed : April 19, 2004

between unit cells during charge/discharge. Cycle life properties may be thus improved for an electrochemical cell in which a plurality of unit cells are combined.

The paragraph beginning at page 34, line 20:

An electrochemical cell was prepared as described in Example 1 without adding any anion-exchange resin to an electrode materials, and was evaluated by a high-temperature cycle test.

The paragraph beginning at page 35, line 4:

In relation to Comparative Example 1, any Example shows better high-temperature cycle properties with a higher initial capacity and a remaining capacityies, indicating the effects of the anion-exchange resin. Furthermore, in spite of the fact that the high-temperature cycle test was conducted at a larger current than usual, significant reduction in a remaining capacity was observed, indicating improvement in high-speed charge/discharge properties.

The paragraph beginning at page 36, line 10:

In Example 3, the anion-exchange resin was applied to the surface layer of the electrode while the resin was blended in the electrode material mixture in Example 5. In other words, it indicates that when an anion-exchange resin is excessively contained in an electrode, properties isare not significantly improved because the anion-exchange resin itself does not act as an electrode active material.

The paragraph beginning at page 37, line 20:

In Example 10, the anion-exchange resin was granular. The test results were not seas good as those from a fibrous anion-exchange resin. It may be because a granular resin has a smaller surface area than a fibrous resin and thus addition of the anion-exchange resin is less effective.

The paragraph beginning at page 39, line 12:

Appl. No. : **10/827,074**
Filed : **April 19, 2004**

| The results demonstrates that this invention can improve a capacity of an electrochemical cell stack and cycle life properties.